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OBSERVATIONS ON

SOME OF THE MORE

RECENT METHODS OF TREATING WOUNDS.

"He jests at scars who never felt a wound."

If we accept as the definition of a wound, in surgical language, *a dissolution in the continuity of living tissues from external causes*, it will be evident that all wounds may be arranged under one of two classes, either as closed wounds or as open wounds. In the former class, although the tissues have been broken down and their integrity destroyed, the elastic skin which covered them remains entire. The air is excluded, and they may be said to be covered in and protected from any injurious influences which might arise from that source; whereas, it is a condition of an open wound, however produced, that the epidermic covering of the body has been divided; tissues which are not fitted to resist the ceaseless influences of atmospheric changes, either chemical or thermal, have been thus laid bare, and a new action established in order to protect and restore the injured parts. In the former class will be found all simple fractures, in which not only are bones broken, and their continuity interrupted, but veins and small arteries are ruptured, and muscular fibre lacerated, as well as all contusions with effusions of blood and lacerations of tendinous or ligamentous tissues. All these injuries may occur without the possible access of air, and must be regarded as wounds, as far as structural changes are concerned, but yet they are closed wounds. On the contrary, in the second class we have compound fractures, fractures simple at

first, but yet complicated by the piercing of the skin by pointed spicula of bone, lacerations from various causes, incised and punctured wounds, and contusions in which, in addition to the disturbance incident to the pressure, the superficial structures have been torn and the deeper parts exposed. Now, in studying the possible results of these two classes of wounds, and the way in which Nature, unassisted in her efforts, proceeds to repair them, it will be well at once to exclude from our consideration wounds of mucous membranes. They form a separate class; they are intermediate in position between closed and open wounds, and the way to treat them, and their natural cure, are peculiar to themselves. In wounds of mucous surfaces, chiefly, perhaps, from the high vascularity of mucous membrane, ulcerative changes very rapidly occur, and our best efforts to secure an adhesive inflammation are constantly defeated. To advance, therefore, our knowledge of the treatment of wounds so as to render it more precise and certain, we must note most carefully the progress of closed wounds, and see how far, by any means, we may be able to imitate the same principles and secure the same results in dealing with open wounds. It is a matter of frequent occurrence to observe how wonderfully patients recover after comminuted fractures and lacerations of deep tissues in the neighbourhood of joints at the time of dislocations, and in our efforts to reduce them. All these may take place without constitutional distress, if no open wound exist; whereas the same injuries, if the surface has been destroyed to a small extent, so that the air reaches the deeper parts, are followed by general disturbance of a serious nature.

Apart from the interruption of the continuity of tissues occurring in an open wound, by which the structures which have to be reunited are widely separated, there must be some special reason why closed wounds pass so harmlessly through the stages of repair, as compared with the progress so constantly exhibited in open wounds. We have not far to search for the possible reason; the access or exclusion of air has long been regarded as influencing in no mean degree the changes incident to the healing process.

An almost instinctive idea prevails that a wound should be covered in, by which not only may pain be relieved, but a better

chance secured of quick recovery; as it has been said, it is the entrance of air into any wound which determines the suppuration: exclude the air, and pus will not be formed; admit it, and the chances that inflammation and suppuration will result are greatly increased. A sort of irritating eroding action has been attributed to the air under such circumstances, and in the early history of the dressings applied to wounds, it is evident that this exclusion of the air forms one chief element in the treatment. This same result was brought about by a variety of means. In its most primitive and simple, yet not ineffective, form it is at the present day practised by the natives of New Zealand, who must needs have gained their experience in the hard school of necessity. I have been told by one of the medical officers of a regiment engaged in the recent war in that country, that the natives treated gun-shot wounds, extensive lacerations of the limbs, and even the compound fractures attendant upon them, by enveloping the part in an immense mass of wet clay, carefully moulded to the shape of the limb. This was put on as quickly as possible after the injury, and kept on without any change for many weeks, until the healing processes had been completely accomplished. Here, unless some special quality be inherent in the clay, it must act simply by the exclusion of the air, and by securing perfect rest to the injured parts. But surgeons could not long remain content with these simple means of cure. We have in modern times at least to take into account the constitutional powers of the person injured, for the same kind of injury may at one time be quickly repaired, whilst at another, or in another subject, it may hardly advance to reparation. So that whilst in past times when the habits of the people were very different from what they are now-a-days, when the mode of life was far less artificial than it is at present, when exposure to the vital stimuli of fresh air, simple food, light, and other health-producing agents, was far more constant, we can imagine that the natives of this country, like those of New Zealand, might have possessed powers of constitutional repair to a far higher degree than we have at the present time. In fact, we see this state of things every day; we find that in large hospitals in the centre of our great towns, not only have

we to deal with the constant effects of an impure atmosphere, but the patients who enter these institutions come in with constitutions already enervated by what may be called an artificial mode of life. Let us consider for a moment the habits of the artisan in any one of our manufacturing towns—the many hours of toil, the close ill-ventilated workshop with its heated atmosphere, the still closer room or bedroom, inappropriate food, an exhausted nervous system kept up to a high state of excessive tension by intemperate habits, or by acute or chronic alcoholism. Let a man thus situated receive an injury, and see how far he will be prepared for the reparative processes as contrasted with the man who leads a country life, and whose wear and tear of body or of mind are not a fractional part of his. Thus it is that surgeons vary so much in the estimate they form of the value of particular modes of treating wounds. The circumstances under which the wounds are to be treated, and the constitutions of the patients to be dealt with must be considered, and for this reason doubtless the means practised in surgery in this respect will ever vary greatly with the class of patients under treatment.

It is notorious that in country practice very simple methods of treatment suffice, whereas amongst the denizens of large towns we have to deal with nervous constitutional irritation, which is difficult to control and most unfavorable in its influences. Hence have sprung up from time to time all that multitude of surgical dressings which have been applied to wounds since the earliest records of the surgical art. And yet in all this variety there is one great principle which pervades the whole. Not only is it the exclusion of air, but as experience must have taught the earlier experimentalists, something more than this is wanting. It is not air as a harmless gaseous compound which is to be corrected, but certain secondary products which it contains that are the source of danger. Decay and putrefaction are to be avoided, and this has been attempted by the dressings which have been used; hence it is that we find, added to the resins and ointments which have been employed, aromatic gums and empyreumatic substances of all descriptions, such as were known by experience to avert putrefactive changes. The history of the

subject teaches us that the management of wounds has constituted at all times a large proportion of the recognised duties of the surgeon, and that (*multi homines, multæ sententiæ*) each surgeon of eminence, and each epoch of surgery have had their own peculiar and prevailing methods. The wine and oil of sacred story, which the good Samaritan is described as pouring into the wounds of the eastern traveller, seem to suggest the guiding principle, and curiously illustrate the fact that in the progress of any discovery, while the dark explorations of the human intellect in its gropings to elicit truth have obscured a subject, it has at last resulted that with the advance of knowledge we have unconsciously reverted to earlier, more simple, and more natural processes. It would be useless to attempt to enumerate one tithe of all the applications which have been used or tried from time to time as dressings for wounds. It may suffice to remark that in the cerates and the ointments, the fomentations and the poultices, the lotions and the plasters, the one idea which pervades the whole is this, that each mode of treatment in some way secures by the exclusion of the air the control of putrefaction. This is, it would seem, the cardinal point to be kept in view in the management of wounds, and the one which it is important to insist upon at the present time; not only because the most successful methods which have been thus far pursued have depended upon this one great principle (perhaps frequently without its full cognizance by those who have adopted them), but also because this exclusion of the air and prevention of putrefaction is of the first importance under all circumstances, even where the atmosphere which surrounds a wound is in its most healthful state, rich in hungry oxygen (ozone as it has been called) and free from all impurities. But far more important is it, and to a far greater degree, where from any cause the air which touches a wound is loaded with the products of disease and putrefaction, where the air is the channel, so to speak, by which the seeds of molecular death can travel on their course from wound to wound. To gain a notion, therefore, of nature's way of healing wounds when unaided by art, and herself quite equal to the task, let us contemplate the changes which occur in every small and simple wound, for, with them as guides, we shall see how far the

same principles are applicable to greater injuries. Let us examine, for example, the reparative changes which take place in the healing of a small incised wound in any highly vascular and vitalised part on some exposed portion of the surface of the body. Small as such a wound may be, it will present many characteristics common to larger wounds. First, there will be the gaping of the skin at the edges of the wound; for the skin, by its elasticity and constant tension, will be retracted to some degree on each side of the incision. Next there will be an escape and loss of blood, since it is impossible for the surface to be divided and the deeper tissues exposed without some hæmorrhage. Lastly, the structures beneath the skin, the cell-tissue, the adipose tissue, and some subjacent muscular fibres will most probably be laid bare.

But whatever they may be, there will still be these matters to be noted,—the gaping of the wound, the bleeding and the exposure of structures, usually covered by skin, to direct contact with the air. See now what nature does in such a case as this. After the first changes have occurred, the immediate hæmorrhage, if the circumstances are favorable, will subside, and if the wounded surface be examined there will be found to lie upon it a clot of blood, and after this exuding from the surface a colourless fluid which is the *serum sanguinis*, escaping from the cut extremities of the divided capillaries. Within a short time this will also cease, in fact it will dry up and with the coagulating fibrine, enclosing the red particles of the blood, and the albumen of the serum, it will form a perfect varnish or cover for this little wound—a beautiful plaster, fully capable, if left to itself, of excluding the air and of protecting the deeper tissues from its irritating effects. With nature's plaster, so to speak, ready formed and adherent to the surface, those purely vital processes can be elaborated beneath it, by which the complete restoration of the normal continuity of the parts may be secured. Now, it may naturally be asked, why will not this same plan serve for the healing of larger wounds than this? Why may not they also be left unassisted to nature's care? The answer to this question would seem to be one rather of degree than of kind. The same principles of healing do apply to the larger wounds, only fresh circumstances are interposed. In the

larger wound, the surface being more extensive, with a greater area of newly exposed tissues and the hæmorrhage more considerable, the blood flows more rapidly and has not time to coagulate and solidify, as far as its fibrine is concerned, before the newly made coverings are washed away by the continued stream. And more important even than this is the circumstance that the coagulum thus partially formed (either from its extent or its thickness) is too great to undergo that rapidly drying process by which its albumen will be converted into a layer of varnish on the surface of the wound; but on the contrary, by remaining as a thick mass at the usual temperature of the surface of the body, it is left in the most favorable state for subsequent putrefaction. The mass thus formed and not dried, lies on the surface as a foreign body, and becomes amenable to all those laws of chemical change which would affect its decomposition independently of the controlling influences of vital forces. The average temperature of the body being a known quantity, a constant factor in these changes, acts either for good, as in the case of the small wound, where it tends to dry up the albuminous part of the escaping blood, and form it into a plaster or protecting shield; or, as in the case of the larger wound, as an element of evil, for then the same atmosphere and its contents, with the presence of moisture, will favour those putrefactive changes which it should be our object to prevent as far as possible. Yet in modern times, and even at a comparatively recent date, surgeons have been found who have advocated the practice of treating wounds, especially those produced in amputations, without any dressings at all, simply by entire exposure to the air from first to last, or at least until a very advanced period in the treatment. In this they acted doubtless upon the principle just enunciated, that if the escape of blood and serum can be so regulated, as to time and quantity, as to become thoroughly dried, and remain in that condition for a certain time, they will prove of all others the best protecting medium for the wounded surfaces. This, however, can only be efficient where the covering thus formed fairly overlaps the edges of the wound, and thus excludes the air from every part; for if there be any portion of it upon which the blood has not thus

dried and hardened the conditions of decomposition will inevitably be there present.

To these conditions, which are three:—decomposable materials, as clots of blood, a certain high temperature (say 90 to 100 degrees), the access of moisture or the presence of the elements of water, there is only wanted (what unfortunately is so rarely absent where extensive wounds is generally treated, viz., in large hospitals) the addition of some putrefiable matter, very minute in quantity, the particles of which are in a state of change, and the circle is complete. Putrefactive changes must then commence and spread rapidly over the wounded surface, until at last by the absorbents or perhaps directly through the veins themselves, the whole body is contaminated with a deadly poison. This is practically the great objection to leaving wounds exposed absolutely to the air, especially in large hospitals. It may succeed occasionally where all the conditions are favorable thereto, but there must always be a risk of an untoward result unless the exposed surfaces be kept perfectly dry, and the air around them perfectly pure.

Having considered in this manner two typical illustrations:—the small wound on which nature's shield, the clot of blood, the dry eschar, as it has been called, is immediately placed to protect and defend it, and the large wound in which from a variety of causes this method will frequently prove to be insufficient, it may be well to pass in rapid review the different means which have been employed by surgeons in unconscious imitation of nature's plans. To take the one to which allusion has already been made—the wine and oil. The wine, as far as the alcohol which it contained, would tend to coagulate the albumen of the blood and serum; and the oil, filling up the recesses and corners of the wound, would act as a most excellent protective covering from the air. In opposition to these remarks it might be said that wine in ancient times was very different in its composition, as far as its amount of alcohol, to modern wine, and richer in saccharine and gummy matters. If this were really the case, thick and viscid wine loaded with such matters would act more as a simple protecting medium for the exclusion of air, just as treacle does when applied to the abraded surfaces of burns and scalds. But

the effects which the oil would have upon the blood with which it might come in contact may be deduced from the ready manner in which blood is so changed. When we bleed a person, and allow the blood thus drawn to flow into a vessel containing oil, the oil floating on the surface of the blood as it fills the vessel materially influences the subsequent changes which it undergoes. Fibrillation is delayed, the red particles, having time to fall through the fluid, collect at the bottom of the vessel, and the blood thus intimately excluded from contact with the air remains for a very long time without undergoing putrefactive change.

It is hardly necessary to remark that, just as in the case of treacle, the good results attendant upon the use of oil in various ways as a dressing to surfaces from which the epidermis has been removed and the true skin exposed as in scalds and burns, sufficiently prove the very perfect manner in which a layer of oil will protect such surfaces from injurious contact with the air. These substances act physically as air-excluders rather than in virtue of any chemical or therapeutic properties, unless, perhaps, that the treacle may slowly undergo some oxidizing process by which the tissues themselves are more effectually saved from irritation, or, by substitution, from direct chemical action.

In a somewhat similar manner the time-honoured, but now discarded linseed poultice may be said to act; it secures warmth and moisture to the part to which it is applied, by which pain is relieved and vital changes promoted, and by its close contact with the surface it also mechanically excludes the air. But more than this, linseed meal in its nature contains a certain quantity of free, oily matter, belonging to the class of drying oils which oxidise very rapidly by exposure to the air, and this no doubt in its turn serves as food for the oxygen, and in an indirect manner help to spare the tissues themselves from excessive oxidation. The yeast or fermenting poultice acts in an exclusive manner by creating around the wound an atmosphere of carbonic acid, which is in itself harmless to the exposed surfaces, but displaces the oxygen; and what alcohol there is in the unwashed yeast as a product of fermentation may stimulate the granulating surfaces to some degree.

The charcoal poultice also brings about a favorable result, in a negative rather than a positive manner, in any influences which it can exert upon the surface of wounds or the secretions flowing from them; for the well-known power of charcoal to absorb certain gases, such as ammonia and sulphuretted hydrogen, many times beyond its own volume, must be the means by which a charcoal poultice seems to clean and purify a wound. And yet, in truth, the changes are still progressing, only the gaseous products of putrefaction are quickly removed beyond the reach of our senses, shut up in a condensed form in the minute particles of the charcoal.

The good effects of wine, as modern wine, when applied to wounds, must be due to the alcohol which wine contains, with saccharine, saline, and gummy matters. The success which attended the alcoholic dressings of Dr. Betailhé, at one time so greatly advocated, seems to prove that alcohol acts on wounds by coagulating, and drying the fibrinous and albuminous constituents of the blood effused upon their surface, and converting them into a thin film or protective covering.

The old-fashioned friars' balsam, once so much in repute as an immediate dressing for wounds, must have acted in a precisely similar manner, only to a more intense degree; for, after the spirit which the tincture contains has produced its influence and evaporated, the resinous matters which remain form an excellent coating to exclude the air, and one very little prone to putrefaction by reason of the empyreumatic substances of which it is composed. But apart from these two healing materials—the oil and the alcohol—for a very long period wounds were treated by all that host of greasy applications, ointments, and cerates in their thousand varied forms which Liston and McCartney did so much to throw into disuse,—the former by his simple warm water dressings, and the latter by his plans of constant irrigation. We have besides in modern times the glycerine treatment of wounds much advocated, and so largely used by Dr. Demarquay, with combinations of glycerine with starch, styled glyceroles, and used as vehicles for other remedies. A slight modification, also, of the water dressing has been made by the addition of aromatic vegetables

to water, forming the elder flower water of Dr. Cusco, of the Hospital of Lariboisière, in Paris. Somewhat on the same principle as this is the plan of applying ice to recent wounds, which needs a passing remark. It answers well enough in good constitutions, where the wound is small and unattended by injury or contusion of the neighbouring parts, but it militates against one of the conditions of healthy reparative inflammation, viz. an exalted temperature; and thus it is apt, unless care be taken, to reduce the vitality of the part and set up other changes, the result of failing life, most difficult to combat.

The use of very strong solutions of chloride of zinc as an immediate dressing to a wounded surface has also been advocated, and it seems to act partly by forming a direct combination with the serum of the blood as some form of albuminate of zinc, and partly by its highly antiseptic properties checking all fœtor and putrefactive changes. It is also very possible that nitric acid in its undiluted form, when applied to a sloughing wound, may arrest further destructive inflammatory changes by coagulating the albumen of the secretions, which are there undergoing rapid metamorphosis; or if the acid be diluted, as in the ordinary nitric acid lotion, the same effect may take place to a less degree with this advantage, that so long as the acid is present it will serve to neutralize the ammoniacal and other acrid alkaline compounds which are the products of the decomposition.

Nor must I pass unnoticed such applications as isinglass and collodion to small incised wounds in which all bleeding has ceased. The one forms a perfect layer of protection, and the other not only does this but also, as it contracts in drying, draws the edges of the wound into closer contact. Wounds have been likewise treated by the total immersion of the parts in oil, or in water. They have been surrounded with an atmosphere in which the vapour of chlorine or iodine has been largely diluted, or which has been made up only of carbonic acid gas, to the exclusion of oxygen; and more recently Mons. Maisonneuve, of Paris, and Mr. Sampson Gamgee, of Birmingham, have placed the wounded surfaces of an amputated limb under conditions of almost entire pneumatic occlusion.

These various examples and many others which might be added

seem to show that in the dressings applied to open wounds these two objects of air exclusion and antiputrescence have been chiefly sought for, and that success has resulted in proportion as these two objects have been attained. In the exclusion of air, or (to speak more correctly) the perfect exclusion of air, there are practically so many difficulties, that for the present it will be well to consider the other point of interest; which is practically the avoidance of putrescence in the secretions of wounds, and to insist upon its absolute necessity. It is hardly needful to remark that as soon as ever the blood or other fluids of the body have escaped therefrom, and have ceased to be enclosed in living tubes and vessels, they undergo certain secondary changes, which are partly vital and partly chemical. The vital changes are manifested by the solidification of the previously fluid portion of the blood, as is seen in the formation of the blood-clot and the subsequent fibrillation of the fibrine. But it is well known that there continues to escape from the cut surface of any part of the body for some hours after it has been wounded, and after the colouring matter and fibrine have become solidified, the watery portion of the blood,—its serum or serosity, so that in this way, the surface of every wound is more or less bedewed with moisture for some hours after an injury has occurred. Now this serum, if exposed to the air, will undergo certain putrefactive changes, unless it be covered in, through that curious solidification of the blood already referred to, by which nature's plaster is quickly formed, although this will only occur in small wounds where the surface is so minute that the drying process can take place. Liebig long ago taught that "the putrefaction of animal matters is a separation or splitting up of their constituents into new and less complex forms. If," he says, "we consider the transformation of the elements of the animal body and waste of matter in animals as a chemical process which goes on under the influence of the vital forces, then the putrefaction of animal matters out of the body is a division into simpler compounds in which the vital force takes no share. The action in both cases is the same, but the products differ. The practice of medicine has furnished most beautiful and interesting observations on the action of empyreumatic substances, such as wood-vinegar, creasote, &c. on

phagedenic wounds and ulcers. In such morbid phenomena two actions are going on together, one metamorphic, which breaks up the constituents of the blood itself under the influence of the vital forces: and another independent of that force. The latter is a chemical process which is entirely suppressed or arrested by empyreumatic substances. And this effect is precisely opposed to the poisonous influence exercised on the organism by putrefying blood when introduced into a fresh wound."

Now it might be asked, in extension of these remarks by so great a chemist as Liebig, What is there in the composition of the atmosphere which sets agoing so rapidly these metamorphic changes? Certainly it is not the oxygen, or the nitrogen, or the carbonic acid and other gaseous constituents of the air which surrounds our earth. There must be present some organic matter which being itself in a state of ceaseless change shall excite, as a ferment, corresponding changes in the fluids recently escaped from the living body. The actual difference between fermentation and putrefaction may be said to be that in the former vegetable fluids and substances undergo change, and in the latter those of animals. There has ever been recognised among chemical physiologists a very close affinity between fermentation and putrefaction. These changes are going on without cessation in all fluid substances which are exposed to the action of the air, and from them there are always escaping into the atmosphere minute particles of vegetable and animal matter, which being in a state of molecular change are capable of acting as ferments or exciters of putrefaction in other vegetable or animal fluids. The atmosphere may be regarded as the great repository of all those matters which are constantly being exhaled from the surface of animal as well as vegetable bodies. To say nothing of the organic secretions of plants, which are quickly volatilized into the atmosphere and effect but little change; or of those more strictly metamorphic products, the result of vegetable decomposition, which seem to cause by their miasmatic influences serious and important changes in the human body, as evinced by the production of those various intermittent and remittent fevers which occur in damp and marshy districts; there are ever passing off from the

bodies of animals, and the human body is no exception, multitudinous matters. The secretions from the surfaces of the skin, the mucous membrane, and the respiratory membrane, and all those excretions which are voided from the body, any one of them in its own metamorphosis may furnish ample material for putrefactive changes wherever it may chance to rest. It is hardly necessary now to refer to Professor Tyndall's observations upon the existence of foreign matter in the atmosphere, in the shape of minute particles of dust and nitrogenized animal substances. That matter in a state of minute mechanical subdivision did so exist has long been known, for the reflection of every sunbeam demonstrated it. What Professor Tyndall did was, by an ingenious arrangement of apparatus, to create at pleasure an artificial sunbeam in which he could exhibit to the eye the presence, under ordinary circumstances, of minute molecular matter in the atmosphere. He also showed that this molecular matter either contained in itself ammonia, which may be taken as the test of albuminous or putrefiable matter, or that ammonia could be derived from it when decomposed by heat. And he further showed that this foreign matter has a tendency to gravitate and fall through the atmosphere, and consequently to deposit itself upon any surface ready to receive it. One cause of its falling will therefore be an increased temperature of the atmosphere, which is equivalent to a decreased specific gravity of the gases. Thus, foreign matter which would remain suspended at a certain low temperature, will fall through the atmosphere rapidly when the air is rendered more tenuiform by increased temperature. Now we know by observation that putrefying agents, whatever they may be, are deposited more rapidly on the surfaces which they attack in a heated than in a cool state of the atmosphere. Nevertheless the effects produced are greatly modified by the nature of the surface.

A very large proportion of this putrefiable matter in the air falling upon the surfaces of inorganic bodies will produce none of the results for which we are about to seek; or if perchance it fall upon the skin uninjured by any wound, we know that this, protected as it is by the horny covering of the epidermis, will resist these putrefactive changes. But if this wondrous covering of the body,

the scarf-skin be removed and the true skin beneath be exposed, then will ooze forth from its surface the fluids before referred to, and these only require to be left in contact with the atmosphere to have excited in them the secondary changes of chemical putrefaction. Let it once be granted that the serum and serosity of the blood, constantly passing out from the surface of a recent wound, can undergo putrefactive changes while in contact with the body, and we may then consider how such a state of things might influence the condition of the deeper tissues and interfere with their healthy action. It is very interesting to observe that these putrefactive changes in the secretions from a wound will always be found most in excess at the edges of the layers of dressings, whatever these may be, where the fluids, in escaping, come most directly into contact with fresh strata of air from which the putridity is derived; so that, if the margins of the wound are free from putrid matter, the centre is almost sure to be so.

To carry out this train of thought we must enumerate the changes in which inflammation essentially consists and their true value in the economy. To the surgeon who has to deal so frequently with reparative processes in the body, the presence of inflammation is in many cases a gain rather than a loss. It is by limited inflammatory changes that injured tissues are repaired, and cut surfaces when brought together are again united; for even if, in every instance, the identical tissue is not re-formed, that which nature supplies is quite equal to its future duties, so that what the surgeon has to do is so to control the inflammation, if too great, that it shall not exceed the required limits of simple reparation. For all the purposes of surgical practice, inflammation may be studied under four conditions:—First, the stage of vascular excitement; secondly, the stage of fibrinous deposit; thirdly, the condition of suppuration; and, fourthly, that state in which the tissues no longer yielding to the control of the vital powers, molecular death takes place, and we have either ulceration, gangrene, or sloughing. Now, it must be noted that in every instance where tissues have to be repaired, we require to have the first and second of these stages of inflammation. We must have a certain amount of extra vascular action, blood must be determined to the part to

be repaired with a little more velocity and to a greater amount than in a state of health; fibrine must be thrown out, and for a time glaze over the surface of the wound, and in many instances act as the protective medium, if this be not effected by the formation of the blood clot. But then arises the third stage of progress, which is so treacherous, and so likely to engage the attention of the surgeon lest it should exceed the limits of health. As soon as suppuration sets in, unless we have some power of moderating the degree of action, it may run on to the condition of molecular death just mentioned. Some have even gone so far as to state that the suppurative changes are in themselves destructive, that, in fact, suppurative secretions from a wound are, as it were, the breaking up of tissue, and that by the fluid so secreted there was necessarily a loss of structure. It will require very little attention, however, to show that such is not the case. Whatever may be the true value of suppuration, whatever may be the true import in the economy of the secretion of pus, most decidedly it is not in itself broken-down tissue. It is one means by which nature expends that over-vascular excitement which has been set up in the first instance. It is a running riot, as it were, of cell-growth, in which, instead of stopping at the fibrinous stage, we arrive at that which is termed the suppurative stage. Yet, if we inquire what pus really is, or what the condition of suppuration really means, all that we can discover is that, as in that other state of retrograde development known as "fatty degeneration," suppuration may be regarded as a degradation of tissue in another form. It is, therefore, a state of things most carefully to be avoided, and by no means to be welcomed, for, as was once remarked in regard to the efforts of the agriculturist, that "he who can make two blades of grass to grow where only one has grown before, has conferred a lasting benefit on society;" so it may with equal propriety be said, that the surgeon who can heal up a large abscess when once opened, or a large wound, as in an amputation where, perhaps, pints of pus had previously been formed, and secure a favorable termination to the case with the secretion of as many ounces or drachms, or, still more happily, by the complete arrest of the suppuration, will have

conferred a lasting benefit on the science which he practises. There is nothing gained by the secretion of pus.

We often hear surgeons speak of what they call healthy suppuration as if the more the secretion the better for the patient, forgetting that for every ounce of pus so formed there must necessarily be a loss of strength to the constitution; more food must be consumed to repair the waste, or the drain will certainly tell upon the enduring powers of the patient. Now, it is very probable that the putrefactive changes which occur in the fluids collected, as already described, upon the surface of a recent wound, become themselves a source of irritation, and excite a degree of inflammation over and above what nature would set up for reparative purposes. We know that in these putrefactive changes ammonia, in some form, is always produced. We know how extremely irritating this volatile alkali is to animal tissues; how even if applied to the sound skin, where the horny covering of the cuticle could protect the subjacent structures, it produces pain and redness almost intolerable; and if its application be long continued a blistering or vesicating effect is the result. If, therefore, in the putrefaction of the albuminous matter on the surface of a wound, ammonia must necessarily be thrown off, this, if it were the only irritating product, would, hour after hour, keep up an amount of vascular excitement in the part, and certainly augment the inflammatory changes, and in this way we should find the inflammation would run on with great rapidity from the fibrinous or adhesive to the suppurative or non-adhesive stage. It may, however, be remarked in opposition to these views that since we have pus formed and suppuration takes place in closed cavities, as in large abscesses or serous sacs where up to a certain time no air can possibly have entered, and where, therefore, no putrefactive changes can have occurred, the suppuration cannot be due to such a cause. But it must not be forgotten, by way of reply to this, that suppuration is but one of the results of inflammation wherever it may exist, and that in the abscess, or in the empyema, the pus is formed, however large the quantity, without the admission of air, and solely as a product or consequence of the previous inflammation. So that when we say that the formation of pus on the surface of a recent wound is due to the

irritation occasioned by the putrefaction of the natural secretions of that wound, it is only the same as declaring that from these putrefactive changes inflammation was set up which ran on to the suppurative stage. If these views be correct, it follows as a necessary consequence that whatever application can be put on a wound, so as to arrest or prevent putrefactive changes in its secretions, will, in the same proportion, regulate the degree and amount of pus that is formed. And it is curious to notice in confirmation of this conclusion, that those applications to wounds, which are themselves the most decidedly antiseptic, are just those by which the secretion of pus is most easily moderated. Of these there are three which we may mention as being most commonly in use, viz., alcohol, the salts of zinc, and carbolic acid. These all act in some mysterious way, the exact details of which are as yet unknown to us, by preventing or checking putrefactive changes.

In the case of alcohol it may be that, from its affinity for water and its power to coagulate albumen, it may rob the putrefiable matter, always present in the air, of its watery elements and arrest in it those changes which act as the starting-points of putrefaction. And the same may be the case with the salts of zinc, the sulphate and the chloride of zinc so well known by their antiseptic properties. I tested the sulphate many years ago, as an injection for anatomical purposes and for the preservation of the entire body for dissection. And the chloride of zinc, so much more celebrated as an antiseptic. Either of these two are most efficient, whether used in the far-famed and well-tried lotion—the red lotion of the surgeon, the lotio rubra of the pharmacologist, or in those strong solutions of the chloride of zinc so much advocated by Mr. Campbell de Morgan. And if we study the mode of action of the other antiseptic,—carbolic acid, under whichever of its many varied forms of application it may be used, as solutions of tarry matter, the tar water of Bishop Berkeley, the creosote lotion of M. Mascharpa, or the mixtures of carbolic acid with oil, glycerine, water, or alkaline solutions,—these all must act, more or less, through their antiseptic powers, in checking those putrefactive changes on the surfaces of wounds which excite and perpetuate inflammatory action; and thus it is, that experience tells us the earlier these applications are

used, and the more carefully they are applied, for the first few days after the reception of a wound, the better chance there is of so keeping the inflammatory changes in check that they shall never advance to the suppurative stage, or if so, only to a very slight and manageable degree; for, when the metamorphic changes in the wound have commenced in suppuration, even here the possible variations are not reached. Beyond the stage of suppuration is the stage of molecular death. Then it is that we have to deal with ulcerations, sloughings, and wide-spreading gangrenes. How much better to prevent this unlimited advance of death by the early use of antiseptics, and before these morbific changes can be established. But here a difficulty arises which all must have experienced who have watched the action of antiseptics upon wounds. Antiseptics may be said to act either directly or indirectly: directly as in watery solutions where they touch the surfaces, and indirectly where they act, by their volatility, in impregnating and filling the atmosphere around the wound with antiputrescent vapour.

Now, where a substance is employed which is non-volatile, it can only check putridity by direct contact, and by the very contact, as in the case of very strong solutions of the salts of zinc, or of pure alcohol, or strong solutions of carbolic acid, the remedy will so far affect the surface as to excite an inflammation peculiar to itself. On the other hand, if we employ substances which only affect the atmosphere surrounding the wound and there tend to neutralise the baneful effects of the putrefiable matter, these agents themselves must needs be volatile, and their effects will be correspondingly evanescent. There is yet another difficulty if alcohol be the substance used, for, although it can be vaporized by the heat of the body, yet if it be applied too assiduously, it will by its evaporation diminish the temperature to a degree injurious to the necessary vital changes in the part. It is desirable, therefore, to obtain some substance which shall, as it were, combine in its properties these two conditions, viz. that it shall not be over-irritating to the surface upon which it is applied and yet by contact shall destroy putridity, and also possess a certain amount of volatility to pervade the atmosphere, and keep the putrefiable

matter at a fair distance from the surface which is in danger. Now alcohol does not fulfil these conditions: it destroys putridity when in contact with animal matter, as daily experience in the preservation of anatomical and surgical specimens in our museums shows; but it is so volatile, and its vapour when diluted possesses so little power to check putrefaction, that it is of little use except when applied directly to the part. The salts of zinc do nothing towards correcting the condition of the atmosphere surrounding the wound, they act only by direct contact; whereas it is possible so to arrange the preparations in which carbolic acid forms a part, that they shall destroy putridity both by direct contact and by atmospheric diffusion. But those who have used carbolic acid as an antiseptic most perseveringly can best testify to the practical difficulties attendant upon its employment. There are some persons in whom the skin surrounding a wound is so delicate, that the mere contact of carbolic acid directly with the surface sets up an amount of irritation and inflammatory change far beyond the parts originally injured; so that in the early employment of carbolic acid in the treatment of wounds, when, unfortunately, it was used far more liberally than was at all necessary, it seemed in many cases to do more harm than good. It caused an amount of irritation and vascular turgescence around the wound which induced many surgeons at once to discard its use, forgetting that this result was caused by the excessive amount of the antiseptic which was contained in the preparation, which ought to have been so diluted that it should just suffice to check putrefaction, and yet not be so strong as to act injuriously upon healthy tissues. Carbolic acid, like many other empyreumatic substances, has this great advantage, that being volatile at the normal temperature of the body, it has a tendency to diffuse itself in the atmosphere at a distance from the wound, but yet this very volatility will cause it in many cases to escape more rapidly than we desire, and in the course of a few hours after its application it will be found to lose its antiseptic powers; in other words, it has evaporated and things are left as they were before its application. What we must seek for, therefore, in all applications of carbolic acid to the surface of a wound is, on

the one hand, to avoid its irritating effects, and on the other, to deal it out at so low a rate, in one continued equable stream, that on its first application it shall not act too powerfully, and yet after many hours, or even days, it may still be present as a protector against putrefaction.

Many, very many, applications all designed with the same object, have been invented by surgeons and those who have assisted in establishing the use of carbolic acid as a dressing to wounds. In the early stages of its use it was employed mixed only with water, or, perhaps, rather suspended in that fluid as a sort of emulsion from which it was apt to separate, or to be set free, as the water evaporated, and to leave the acid as a deposit of too great strength upon the surface to which it had been applied. It was then proposed to mix it with glycerine, or some alkali like potash and water, to correct this effect, while experience afterwards told us that this might have been prevented by having the acid more diluted in the first instance. Various preparations, containing oil and greasy matter as their basis, were next employed as vehicles or media for the diffusion of the acid, and the one which, even now, is in frequent use as the most simple and readily applied, is an admixture of the acid with common olive oil, or linseed oil, in certain proportions. It can be made of any strength, or when too strong can be easily diluted, as carbolic acid is freely miscible with oily or greasy matters. This is, very probably, the reason why we can always use oily solutions of carbolic acid of greater strength than those in which it has been mixed with water; because, in the latter case, the water drying up, in some degree, after the application, the lotion is rendered, in effect, of greater strength and more stimulating than when first applied; whereas, with oil as a menstruum or solvent, oil being non-volatile, any change of strength can only be due to the loss of the carbolic acid itself. Oily or greasy applications for wounds have always this one advantage to recommend them, that, if they do not irritate by becoming rancid, they can, at each dressing, be removed from the delicate surface of the part, with little pain to the patient.

Rather more than twelve months since, I suggested the use of an application to wounds which I called cere-cloth, and which

was made up of paraffine as a basis, mixed with oil, wax, and carbolic acid. Thin calico, or linen, being saturated with this compound when liquefied by heat, could be used very conveniently as a covering to wounds where antiseptic action was desired. It seemed at first to answer this purpose very well; but I soon discovered it had this great defect, that it allowed the carbolic acid vapour to pass off too rapidly. Vaporised by the heat of the body in the first few hours after its application, the stimulating effects of the acid were excessive, after which, when much of the acid had been in this way lost, the cere-cloth no longer possessed the desired amount of antiseptic power. Thus, when applied to wounds, it, at one time, stimulated the surface too highly, and when this was past, in the interval of the dressings, it allowed putrefaction to recur. A very short experience of its effects, therefore, showed me that it was not the application for which I sought. But, long before I had entered upon these experiments, Prof. Lister of Edinburgh had taken up the subject and followed it out with a praiseworthy amount of tenacity and perseverance. I may here remark, however, that I did not lose much time in following in his track. His first series of cases of successful application of carbolic acid to wounds upon antiseptic principles was published in the 'Lancet' of 16th March, 1867. Very shortly after this was issued, a patient was admitted into the Manchester Royal Infirmary, under my care, with a punctured wound and laceration of the wrist joint, which was so opened that the finger could be passed into it. The injury was so considerable that, under any other circumstances, amputation would have been deemed necessary, but, having only a few days previously read Prof. Lister's remarks, I at once proceeded to dress the wound in the manner he had detailed, and the result was that the patient recovered without one bad symptom, and with a useful joint in which all the natural movements were preserved. From that time I have worked unceasingly on the same principle, always keeping in view the one great point to be attended to, namely, that it is not carbolic acid as a special means which is to be regarded as so serviceable in the treatment of wounds, but the power of carbolic acid or any other substance which may hereafter be suggested as

better than it, to check, and, if possible, destroy entirely, the tendency which exists in the secretions of wounds to undergo putrefaction.

As soon as we clearly comprehend this object, the particular method of accomplishing it will resolve itself into a matter of detail. No plan has attracted greater attention than that which has been so much advocated by Prof. Lister, and to which the late Mr. Syme added his valuable testimony, with the pointed remark that he "regarded this system of treating wounds and surgical cases, as one of the most important improvements in surgical practice of recent times."

It may be well to recur again to the way in which putrefaction is brought about in animal substances generally. There are four conditions required for the development of putrefaction to its full extent, each of which is alike essential. In the first place, there must be animal matter ready for putrefaction, for all animal fluids or solids are not equally disposed to this change, and as far as fluids are concerned, the condition of nerve-power in the constitution of the person secreting them will influence the result; secondly, a certain high temperature is requisite for the development of putrefaction; thirdly, the presence of moisture; and fourthly, the access of air, not to mention germs or fermentable matter. Now, if any one of these four conditions be deficient, putrefaction will be retarded; if more than one be imperfect, it may possibly be avoided altogether. Thus, with regard to the preservation of animal substances, muscular tissue, gelatine, &c., if they are rapidly dried at a low heat, and the watery element which enters so largely into the composition of even the most solid of animal tissues be entirely removed, no putrefactive change will take place. Or, if a certain temperature be not attained, if the animal matter can be preserved at a temperature a little above that of the freezing point, say from 30° to 40° Fahr., putrefaction will not occur: most decidedly it will not occur where the animal matter is retained at a temperature below that point. This is well known to those who have lived in colder climates than ours. In Canada, for example, it is not at all unusual for meat for domestic purposes to be purchased in a frozen state and placed in an ice house, where it is

kept until required for use. It is then very slowly thawed, and, as is absolutely necessary, it is cooked immediately; for though quite free from putridity, putrefaction will much more rapidly ensue than if it had not been previously frozen. And lastly, the entire absence of air, effected in various ways, will avert putrefaction. If animal matter be immersed in glycerine or oil, or entirely wrapped up in some impermeable covering, it is possible to preserve it, at any rate, for a length of time from putrefactive change. But in many of these cases, where air is said to be excluded by mechanical means, a drying process goes on without our knowledge, and it is not only the absence of air which has prevented the putrefaction, but also the absence of moisture. In addition to the presence of animal matter disposed to putrefaction, it would seem that, to start or set going this process, there must be brought into contact with the animal matter other animal matter, itself in a state of chemical change. This peculiar condition was well pointed out by Prof. Liebig when he first enunciated his theory of putrefactive change in animal matter. Animal matter in a state of chemical change will excite in the particles of the constituents of any other animal matter brought into near contact with it, a similar disposition to re-arrange themselves in new and simpler forms. These changes being once established, appear to propagate themselves from particle to particle until, at length, a large portion of the surface of the animal matter, or perhaps the whole mass itself, has become thus affected. That an extremely small quantity of matter in a state of change, often inconceivably minute, is enough to excite a corresponding change throughout the whole of a large mass, can be demonstrated by one or two very simple experiments. In the case of vegetable matter it has been shown that, if freshly expressed grape-juice be placed in a suitable receiver over a mercury bath, it will remain unaltered for an almost indefinite time; no gas will be given off, and no evidences of fermentation will be seen, and the particles of the grape-sugar will not be converted into their alcoholic representatives. But if only a single bubble of air, of the smallest size, be allowed to enter the receiver and rest on the surface of the juice above the mercury, within a short time, if a proper temperature be sustained, fermentative changes will commence in

a portion of the grape-sugar of the juice; this will set up a similar change in another portion, and so this tendency to change will spread from particle to particle until, at last, the whole quantity of grape-juice, shut off from external influences, will undergo complete alcoholic fermentation.

Now the changes of putrefaction I apprehend are very similar in nature to those of fermentation. I have taken pieces of freshly cut meat from the centre of a large mass, and quickly slipping them through the mercury under the receiver of a mercury bath, they were immediately seen to be floating on the surface of the metal beneath the glass receiver. Left there for four whole days, no perceptible change could be observed in the meat; no gas had been disengaged, (for every particle of it would have been collected above the column of mercury had any been set free,) and to all appearance no change had occurred in the colouring matter of the blood in the tissues of the flesh, or in the fluid which had escaped from them. At this time, by means of a curved glass tube, I caused a single bubble of air to pass through the mercury in the receiver, and to come in contact with the meat, which was then left without further disturbance. In a few hours it was apparent that chemical change had commenced; the meat had lost its fresh pink colour, a somewhat ashy dirty appearance came over it, the red coloured serum was absolutely blanched, and from the downward pressure on the mercury, it was quite evident that the gaseous products of putrefaction had been evolved, and a chemical metamorphosis was being established. In the course of the next five days a considerable volume of gas had accumulated within the receiver, and when this was removed from the bath and the meat exposed, the smell of putrefaction was quite perceptible, while the acetate of lead test gave proof of the existence most clearly of sulphuretted hydrogen, with, possibly, some ammonia in combination with it. Now, these two experiments demonstrate the perfect parallel that exists between fermentation and putrefaction, the one with vegetable and the other with animal matter, and also serve to show how small a quantity of the excitant of these processes, when once allowed to rest on a suitable *nidus*, can, without further addition, go on developing itself to an unlimited degree, so long as its appetite for

chemical change remains unsatiated, or the conditions under which those changes have occurred are not positively interrupted. Much has been said lately about the presence, in fluids undergoing putrefactive changes, of certain animated vitalised germs, endowed with powers of independent motion not easily distinguishable from mere molecular movements with which, in many cases, they may be confounded, and that the presence of these germs is inseparably connected with the phenomena of putrefaction. But, it is well I should here remark that, my observations have led me to the conclusion that the presence of moving vitalised germs, in animal secretions, as a cause of putrefaction, must be looked upon rather as a condition circumstantial than essential to such a change. It has been taught that, in the decomposition of vegetable matter in alcoholic fermentation there must be present, as a starting-point of the process, that curiously organised body known as the yeast-plant or the *torula cerevisiæ*, and some have assumed that septic vitalised germs would take the same place as it, in developing the phenomena of putrefaction. In the fermentation of beer, and possibly of other fermentable liquids, yeast is employed to set in action the changes which we contemplate, and the yeast-plant is itself reproduced as a consequence of their elaboration; so that, commencing with the one small particle of yeast, it is possible for it, in the progress of fermentation, to germinate into immense masses far beyond its original amount.

Nevertheless it may be said that the presence of this yeast-plant is rather circumstantial than essential to the fermentative change, if it can be shown that fermentation does sometimes take place without its presence. Now it is possible to have vegetable juice with saccharine matter slowly undergoing alcoholic fermentation, without the addition of any of the yeast-plant to the fluid. The presence of the yeast-plant is, therefore, not an essential but rather a very common attendant condition on the vinous or alcoholic fermentation, and in like manner it would seem that in the putrefactive changes which occur in animal matter the starting-point is rather the animal ferment in a state of change, which, being brought in contact with other animal substances, determines rather by chemical than by vital action their resolution into other compounds. Yet, as the

putrefaction advances, the germs of these minute organisms, ever floating, as we believe, with other extraneous matter in the atmospheric wave, will fall upon the putrefying surface and there find congenial soil on which to fructify and grow, without being essential to the changes, but rather accidental attendants upon them. I have myself observed, with considerable care, the solid constituents of the atmosphere in the wards of our infirmary, and by repeated washings of the air so examined, I obtained a peculiar white cottony-looking substance which was thrown down, at the end of thirty-six hours, from the water I had used. In this semi-fluid matter for some time no traces of organised life could be recognised; but under a moderate temperature in a carefully closed vessel and with the presence of moisture, in less than twenty-four hours it could be seen with the microscope that the mass was permeated by particles of matter endowed with independent motion. These very shortly afterwards could be identified as the most simple and lowest forms of animal life—the *vibriones* and the *bacteria* of microscopists. Had these fallen upon a mass of putrefied animal matter, they might, possibly, have germinated and grown with even greater rapidity than in the pure distilled water by which they had been collected from the air. Thus it is that these germs can only be discovered under certain conditions, viz. where they have found a suitable nest for their development. Myriads of them are lost to view by being deposited on surfaces or under conditions unfavorable to their growth, while to some it is putrefying animal matter, to others fermenting vegetable matter, or even peculiar kinds of such matters to which certain forms attach themselves, to the exclusion of others, on which alone they can be developed. And yet, in all these growths, whatever they may be and various as they certainly are, they are not the first step in putrefactive changes, but only early attendants upon them, and the true source of putrefaction must be sought for in the contact of animal matter, already itself undergoing molecular change, with animal matter no longer able to resist such change by the contending influence of the vital force. If we consider how the whole surface of the body is protected on the exterior by the horny layer of the cutaneous epidermis, and on the

interior by the epithelium and the mucous surfaces with their peculiar and generally alkaline secretions, we can understand how, possibly, neither of these two surfaces, the skin or the mucous membrane, are, under the ordinary conditions of health, suitable for the development of these vitalised germs. But, so soon as we have to deal with an open wound instead of a covered one, viz. that solution of continuity in animal tissue in which structures unaccustomed to atmospheric contact are suddenly exposed, then it is that we get those changes, at the outset purely chemical in their nature, to which I have particularly referred at the commencement of this paper.

The hypothesis which I would advocate, and the view which I should be most disposed to adopt, as to the cause of the putrefactive changes which occur in the secretions of wounds, is, that so long as the air is excluded, and by that means the putrescible matter which it contains does not come into contact with the surface, nature, (equal to her task) in her attempts to repair the injured tissues, sets up what are called healthy inflammatory changes, and these are kept within the limits of simple repair. On the other hand, if the putrefiable matter which falls upon the wound is allowed to produce a chemical change in the secretions there formed, they, thus vitiated, react upon the surface, excite an undue amount of vascular action in the part, and hurry the second stage, which is the one in which lymph is deposited, on to the third, in which we have to deal with the secretion of pus, or even to the fourth, in which we watch the advance of molecular and structural death. Acting upon this theory it becomes our duty to inquire how best we can avert these objectionable conditions. Professor Lister has guided us by his suggestions as to the use of a certain antiseptic which, when brought into contact with animal matter, will arrest the chemical changes which are the very essence of putrefaction. The substance which Professor Lister has found most useful for this purpose, and with which he has laboured most unceasingly is the carbolic acid of modern chemistry. This substance differs but slightly from creasote, long known and long employed by surgeons to render putrid wounds less offensive to the smell and less injurious to the system. But creasote possesses to

an extreme degree that quality of which carbolic acid is not entirely deficient, namely, a tendency to irritate and itself produce inflammation of the tissues to which it is applied. I doubt not, if the same careful experiments had been made with creasote as have been carried out with carbolic acid, very similar results would have been arrived at. Carbolic acid, however, is more manageable, it is more readily soluble in water, miscible to an almost unlimited degree with oil, glycerine, and alcohol, and, by reason of its greater purity as a chemical preparation, it can be made free from extraneous irritating matter. Thus, when these two bodies are placed side by side, although, in some respects, they possess a similar nature, carbolic acid seems to have many properties to recommend it which are absent in creasote. In the use of carbolic acid in the treatment of wounds, as I have already stated, we must never forget to take every care that it shall not produce injurious effects upon the surrounding healthy tissues, and that it shall be used simply to check putrefaction, for this is its special mission of usefulness, and, this result secured, nature will do the rest. But here great difficulties, all of a practical kind, will meet us on every side, and much credit belongs to Professor Lister, to whom the profession is largely indebted for the great efforts he has made, with untiring industry, to work out his theory and overcome the difficulties. At the present time it would almost seem as if the El Dorado had been attained, for, by means of the most recent dressings which he has introduced, the lac plaster and the oil-silk protective, it may be fairly hoped we shall now be able so nearly to adjust the action of the antiseptic to its antiputrescent requirements and yet guard the tissues from injurious action, that we may steer a middle course and gain the object so earnestly sought for. But, it behoves the surgeon, who first attempts to put these principles into practice, that he should not be disheartened if he only secures a portion of the good results which, upon very creditable authority, are declared to have been produced by careful adherence to the mode of dressing wounds suggested by Professor Lister. Not only will he soon find, to his great reward, that in the management of wounds on this plan the amount of discharge, even if we deal only with the serosity or serous discharge from wounds,

is materially diminished, but the unpleasant and often sickly smell so common to them is entirely avoided, and if pus be secreted (which, in spite of all our efforts, will sometimes be the case) it will not only vary in character from the ordinary pus of a suppurating wound, but will also be of comparatively small amount.

There is a peculiar form of purulent secretion which takes place in wounds submitted carefully to the antiseptic treatment which is worthy, I think, of a passing remark. Instead of the pus, which is thus occasionally secreted, being of that creamy, semi-fluid consistence with which we are all familiar, the matter formed under these circumstances has much more the appearance of mucus than of pure pus, and for this reason I have called it *mucoid pus*, to indicate this character; that is to say, when dropped upon any surface it falls down in thick lumps or masses, having considerable tenacity, so that it looks like flakes of lymph mixed with pus, or a secretion transitionable in its nature between lymph and pus. So soon as ever the surgeon perceives this peculiar secretion on the dressings of a wound thus treated, he may be certain that the wound is going on favorably, for it is under the influence of antiseptic action which restrains the inflammation, and by a little more care in the management of the antiseptic the secretion of mucoid pus will cease entirely; nothing but pure lymph will cover the surface of the wound so long as this continues, and repair will advance in a satisfactory manner.

Whilst, however, it must be admitted that the theory upon which we rest in advocating the antiseptic method is that the causes of suppuration, ulceration, and gangrene in wounds, are external to the body in a very large majority of cases, it cannot be denied that all of these conditions may arise from influences which exist within the system of the patient himself, and are therefore beyond the control of external applications. Let us imagine, for example, that from some cause, in an injured limb, the nervous and vital forces have been in an imperfect state of intensity at the time of the accident, and the powers of repair insufficient for the occasion, no external application would give to the system that vital reparative energy of which it is then so much in want. The limb may have been seriously crushed or bruised;

some large nerve going to the part itself may have been destroyed; or an artery in which disease before existed may have become blocked up or broken through. In such a case it may be said that the source of all the failure in repair proceeds from within, and the injured part imperfectly supplied with blood by a damaged artery, or its nutrition interfered with by the division of a nerve, might quickly develope all the conditions of rapid mortification.

Here, then, we have a proof that defective repair and some of the worst consequences of inflammation may be brought about by internal causes as well as those which are external to the body. All that we can hope, therefore, by careful application of the antiseptic treatment of wounds, is, in any given case, by the removal of all external sources of mischief, to make the open wound accomplish its repair as the covered wound would do. We know it is not in every case of covered wound, or extensive contusion, that nature really can do all. In some of them suppuration will take place in spite of every care, while in others, possibly from the injury to the nerves and vessels, sloughing and even gangrene will occur. Under such circumstances we can only strive, by attention to constitutional measures, to avert such serious results. Thus, we freely admit that the changes we desire to avoid will sometimes take their rise from internal rather than from external causes. Yet, no one who has watched, for many years, the course of events in the surgical wards of a large hospital, can have failed to have his attention riveted to the fact that, in a very large number of cases in which wounds go on badly, the unfavorable change is due to the vitiated atmosphere by which they are surrounded—an atmosphere, it may be, which is a source of constant irritation to the delicate surfaces of secreting structure, being loaded with excess of animal matter emanating from the bodies of other patients, animal matter itself in a state of *eremacausis* and ready, therefore, to set up similar changes in any animal fluids with which it may be brought in contact. It is evident that the unhealthy state of wounds in large hospitals, where not produced by direct contact with poisonous matter, generally depends upon one of three causes—overcrowding of the sick, by which there will be, in the atmosphere, a large amount of putrefiable matter; in-

creased temperature, by which putrefaction will go on more rapidly, as is the case in the summer season or when the weather is unusually sultry; and thirdly, a peculiar condition of the atmosphere, which would almost suggest the idea of its being in some abnormally electric state, as, for instance, before the advent of great thunder storms or sudden atmospheric changes, when, in one night, all the wounds in a hospital have suddenly assumed that fearful condition known as hospital gangrene, which at times has decimated the wards of some of our finest hospitals, and frustrated the efforts of the best of surgeons. It is, therefore, in order that we may be prepared for these effects, that we seek to encase our wounds in an atmosphere unfavorable to putrefactive change. At present, the result of my observations, which have now extended over more than two years, have more and more convinced me that, although we may yet fail in detail, as, alas, we do in many cases, the principles of the antiseptic treatment are essentially correct. How long carbolic acid shall be the agent we employ, or how far the researches of modern chemistry may, perchance, discover an antiseptic devoid of some of the objectionable qualities I have already named, it is impossible to say; but, it is quite clear that, in order to simplify the treatment of open wounds and render them more uniformly healthy, it is needful the surgeon should strive, in every way, to prevent the putrefaction of the secretions of wounds in the treatment of surgical cases.

To illustrate the extreme importance of avoiding the slightest contact of putrefiable matter with the surface of an open wound, we have only to consider the dangerous results which have followed where a dirty sponge, a soiled cloth, an unwashed probe, or any instrument which has been in contact with animal matter in a state of decomposition and putridity, has been allowed to touch a recent wound. We know what takes place, in our dissecting rooms, when the finger of the student is accidentally wounded by a scalpel, which has carried on its edge an infinitesimally minute quantity of animal matter in a state of putrefaction, yet, small as it may be, quite enough in amount to give rise to the most severe and even fatal inflammation; we have seen it also when the

matter has been obtained, not from the fluids of a dead body, as in the dissecting room, but from those in the living and apparently healthy state. It is not long since we had to deplore, in this very neighbourhood, the death of a surgeon in active practice and deservedly respected, who, from merely wounding the thumb of one hand with the point of a needle used at the close of an operation, thereby conveyed into his system a portion of poisonous matter too minute to be realised, as to quantity, by any senses we could bring to its examination, but yet sufficient to excite in the part so injured that peculiar form of rapid inflammatory action which led, not only to the local death of the part affected, but to fatal contamination of the whole system.

If the possibility of minute quantities of animal matter setting up such extensive changes be doubted, the answer is that we see it every day in the phenomena of vaccination. Who can measure the quantity of lymph which is really necessary to bring about, in the system of an infant, the preservative changes which we hope to secure by the operation of vaccination? Is it the tenth part, or is it the hundredth part, of a drop of lymph which will thus suffice? If, therefore, so small a quantity of animal matter from one body peculiar in its nature, can set up such extensive and lasting constitutional changes in another organism, who can say what measures, however minute, are superfluous or unnecessary, by which, in the treatment of wounds, cleanliness shall be observed and the presence of foreign matter avoided, either by direct contact or by atmospheric transmission; or that such effects are unworthy of the attention of the surgeon?

With regard to the employment of the antiseptic method, I may remark, as the result of my experience, that it is peculiarly applicable to the wounds which result from compound fractures, and also, as Professor Lister first taught, to the management of the wounds and the after-treatment of large abscesses. But, as yet, I have met with so many practical difficulties in the treatment of larger wounds (as in amputations) that, it may be well to consider upon what these difficulties chiefly rest, in the hope that on further experience they may be removed.

In the case of compound fractures the wounds attendant upon

them are of a peculiar nature; for it is the deeper tissues which are generally the most severely injured. We frequently have in a compound fracture a very small external wound and a very small aperture in the skin; whereas we know that the deeper structures themselves, which are more immediately in contact with the fractured extremities of the bones, are the most seriously disintegrated, and in them, truly, a dissolution of the continuity of tissue may be said to exist most completely. Yet these are the wounds which yield the most favorable results to the antiseptic treatment. The reason is obvious. The door of communication between the deeper portions of the wound and the external air is in many cases comparatively small; a deeply excavated cavern of injured tissue exists beneath the surface, but the aperture of entrance is very minute. Therefore, as soon as, by any means, putrefaction can be prevented in the deeper recesses of such a wound, it is easy to shut off communication with the external air and to preserve these tissues from subsequent injurious changes. Again, in the treatment of large abscesses the incision which we have to make is small in comparison to the cavity of the abscess. If, all those precautions be taken which Professor Lister has so ingeniously suggested, the curtain of lint, the exclusion of air by the stratum of oil itself rendered antiseptic by admixture with carbolic acid, the entire emptying of the sac of the abscess by firm pressure against its walls—a mode of treatment never before put into practice so earnestly, because under the older plan, if such pressure had been made, as soon as ever it had been released air must necessarily have been drawn in by the elastic expansion of the walls of the abscess. Yet, by this method, we may, by steady pressure, completely empty the cavity of a large abscess of all its contained fluid, and the sides, being brought into near contact, early union by organisable lymph and closure of the incised wound which we have made artificially, will be certain to follow. At this spot, indeed, union is speedily effected, since, no putrefiable matter being allowed to develop itself in the neighbourhood, by reason of the antiseptic, the inflammatory changes do not pass beyond the stage in which adhesion takes place, and after which the secretion of pus begins. In every form of

wound we meet with, in which the external aperture is small and the cavity large, the antiseptic method of treatment can be undertaken with every prospect of success.

But the wounds which result from amputations are almost necessarily of a different figure to those just named; they present large apertures or openings and extensive surfaces, which, at least at the time of the operation, will be greatly exposed to atmospheric influences. With all the precautions we can take during the operation to render the atmosphere which surrounds the exposed wound completely antiseptic, it almost invariably happens that, some little portion of such a wound escapes this protective influence, and no sooner have we closed it up and brought the edges together than those parts, which have not been rendered antiseptic, begin to take on putrefactive action. It is in these places, therefore, at the bottom of the wound in its deepest recesses, that the danger arises, and here it is that those changes commence which terminate in suppurative or even gangrenous inflammation. It is true that, in our attempts to close large wounds resulting from capital operations by sutures and other means, we try, as far as possible, to render them of the same form as that to which I have already referred, namely, to reduce the orifice, while a central cavity still remains, so that in all the applications which we have afterwards to apply, we can only get them into actual contact with the orifice of such a wound, and not with the deeper parts. These have been more or less tainted by the impurities of the air, they retain the morbid matter which then has full play, and produces at last exactly those pernicious results which we are most anxious to avoid. It must, therefore, I think, be evident, giving every credit to the careful suggestions which Professor Lister has made, that wounds resulting from amputations are, at the present time, and, I fear, will be, the most difficult to treat upon antiseptic principles. There is one other cause why they are so, and why their progress should be less satisfactory than that of other wounds, and it arises from the difficulty which we experience in the after-treatment, in watching from day to day, their actual condition without unduly exposing them to the air at the time of such inspections. Professor Lister has suggested one or two very ingenious plans by which wounds, under

these circumstances, can be partially uncovered, and yet all the while be retained in an antiseptic atmosphere, so that we may gain some notion of their daily progress. Still, with all these precautions, we can never use that manipulation in moulding a stump when thus treated, which is often of so much advantage in the concluding stages of a case of amputation.

It has been often remarked that under the antiseptic method of treatment, although great success attends the early progress of wounds, it would seem as if, in the later stages, the perfect closure and ultimate cicatrization are delayed considerably beyond the average period. And in many cases it really is so, as if the over-stimulating action of the antiseptic which had been used had interfered with the formation of the new skin and epidermis. This over-action may be corrected by the interposition of a layer of oily matter, as in the oiled silk protective of Professor Lister, which dilutes the carbolic acid and very generally removes this difficulty. Yet, there still remains the fact that, the final healing of wounds so treated may occupy more time than under other methods. It therefore often becomes a matter of some difficulty for the surgeon to decide, when he has applied the antiseptic method to any large wound in its early stage to prevent extreme secretion of pus or the sloughing and death of tissue, whether or not it is for the interest of the case, at a later period, to cease to use the antiseptic, and to employ some other means of expediting the closure of the wound. For my own part, although in a great many cases of amputations, of wounds after the operation for the removal of tumours and the like, I have allowed the wound to close up entirely under the antiseptic treatment, I have used, in some few cases, when the cicatrix was nearly complete, the red lotion to which I have already referred, or at other times, with considerable advantage, the old-fashioned blue lint put on dry, and allowed to adhere to the granulating surface. As soon as this has become firmly fixed by the dried secretion which has formed beneath it, I clip off any loose edges of the lint, so as to leave on only the portion which has adhered and which has formed a sort of artificial scab or encrustation on the surface of the wound. Over this I place, as may be needful, a little dry lint or cotton wool, and I find that, with

a little care, complete cicatrization may be brought about in a satisfactory manner.

If we are thoroughly impressed with the fact that, putrescible matter does exist floating about in the air at all times, more under some conditions of the atmosphere or in some atmospheres than in others, it will be evident that it may gain access to such surfaces as we designate open wounds, in a thousand different ways. This putrescible matter can be well imagined adhering to the surfaces of our instruments, our sponges, ligatures, and needles, or to be present on the surface of the hands of the operator and his assistants, and to be transmissible by contact to any substance it may reach. We are therefore compelled, if we attempt to avoid the application of putrescible matter to the surface of a wound, to seek for every possible source by which it may have entered, and if one of these be overlooked or allowed to pass by unnoticed it will prove as injurious to the result as if a larger number had been similarly disregarded, so much so, that I can well understand that the surgeon who adopts this method for the first time and then reviews the steps of the operation after its performance will reproach himself with the certainty of failure, seeing there are so many chances of ingress for this putrefiable matter to lay the seeds of putrefactive change. It might be thought that the syringing of a wound with an antiseptic fluid at the time of an operation and the covering of it afterwards with layers of lint or other material steeped in the same protective, would be sufficient to prevent putrefaction in the tissues so treated. Yet, if we examine carefully, we may find that in treating the wounds by such a means it may have happened, in spite of every precaution, that a bubble—it may be half a one—of air carrying putrid matter in suspension may be detained beneath these coverings, and reach the deeper structures far away from that part to which we can afterwards apply our dressings. It is only in this way that we can explain how suppuration so often occurs in wounds which have been most carefully covered in at the time of an operation with every precaution taken to protect the surface, and yet purulent formation is afterwards developed in the very bottom of the wound. This must be due to something which has acted after some such manner

as I have deseribed, and penetrated into the deep parts of the wound while the operator was engaged in warding off impurities from the surfaee only. Professor Lister has remarked, that no one will sueeeed in the antiseptie method of treating wounds who is not a thorough believer in the theory that the germs of suppuration exist at all times in the atmosphere; that these germs are so exquisitely minute as to be utterly beyond the ken of human observation; that, therefore, they are to be inferred rather from their supposed effeets than in any way to be positively demonstrated. In all this I thoroughly agree; the only point in whieh I do not feel myself prepared to aequiesee, and for whieh I do not see the neeessity, is the idea that germs of animalised life are the causes upon which these ehanges depend. I would rather assume, as I have tried to prove, that it is the rapid putrefaetion of the seeretions of wounds whieh themselves reaet upon the seereting surfaees, and urge on the reparative ehanges of inflammation one degree too far, from the stage of adhesion to that of suppuration, or, still worse than this, to uleeration, gangrene, and death.

ON EXCISION OF THE KNEE-JOINT.

I am anxious to place on record the particulars of a case of excision of the knee-joint which has lately been under my care in the Manchester Royal Infirmary, as it illustrates the success which may be attained by a strict adherence to the antiseptic method of treating wounds, and at the same time serves to show the complications and difficulties which sometimes arise where this plan is attempted. I will not enter here upon the important subject of deciding how far it is desirable in any case to elect between the two operations—amputation of the thigh or excision of the knee. Excision of the knee is an operation not applicable to early life if it be found necessary to remove any large portion of the articular extremity of the bones, for, it has been observed that, under such circumstances, an arrest of development of the limb in its axial line is very likely to follow, long after the operation itself has terminated successfully. Each case, therefore, must be dealt with upon its own merits, although general principles may be laid down by which we may determine whether any given case be suitable for excision, or whether amputation of the limb be the only operation to be entertained. The question being still an open one, I will not enter upon it at present or discuss the subject.

The case I am about to describe is that of J. B—, aged about 22 years, a weaver by trade, and apparently of healthy constitution. He first came under my notice in April, 1866, when he applied as

an out-patient, stating that some time previously he had been seized with severe pain at the back of the right knee-joint, which was not caused by any blow or other injury, but, as he thought, from over-exertion in standing at his work. This symptom continued for nearly two months, and when I saw him he was unable to walk without considerable pain. He was advised to go home and let the limb rest for a time, and it was placed on a splint and fixed with plaster and bandage, so as to keep it perfectly still. It did not then appear that any inflammatory action had been set up, for at the end of about six weeks he was so far improved that the splint was removed, and he was again able to return to his work. From this time, he continued at work for nearly six months, when the knee became inflamed a second time without any assignable cause; he had recourse again to the same simple method of perfect rest, with a good result, so that I did not see him for nearly a year from the date of the first seizure. When he came to the hospital on this occasion the knee was found to be somewhat enlarged, chiefly in the tissues around the ends of the bones; there was no evidence of effusion in the joint, but there was a certain feeling of stiffness and inability to move it without some degree of pain, yet this was always relieved by rest. His general health was not much disordered, he was slightly anæmic, and for this I gave him the iodide of iron and other chalybeates; the knee, once more protected by a back splint, was kept at rest, and very shortly after this he managed to go again to his work. In the month of April, 1868, two years from the time I had first seen him, he presented himself for the third time at the hospital, and it was then evident that, although he had borne these recurrent attacks of pain with great patience, matters had now gone so far that it was impossible for him much longer to continue to earn his livelihood at his usual work. I therefore made him an in-patient, and the condition in which I found him was as follows :—

There was much swelling over the whole of the knee, slight effusion external to and within the joint, but no very great enlargement of the bones themselves. He could flex and extend the knee to a good angle without much difficulty, the chief pain he complained of being caused by sudden startings of the limb, which

occurred at night, and which distressed him very much. He was placed in bed, small blisters were applied at intervals to the joint, and cold lotions around it. Once more the symptoms subsided, but yet the knee continued of unusual size. It was about this time that, to relieve these pains and spasmodic startings, I applied the actual cautery, in the form of Corrigan's button, on several occasions with very great benefit. It gave great relief to the pain, his sleep was less disturbed, his health improved, and after rather more than a month's rest in bed the joint was put up in Scott's ointment, carefully protected by a light splint, and the patient was again enabled to go home into the country. I saw very little of him from that time till the end of the year 1869, or about three years and a half from the first indications of the disease. It was now apparent that the continued pain was telling seriously upon his health, and he entered the hospital with the firm intention of submitting either to amputation of the thigh or excision of the knee-joint, as might be found practicable. With this object he was admitted on the 14th of February last, and the only perceptible difference in the condition of the joint from that in which it was ten months previously was greater tenderness, larger girth, and more pain from nervous startings at night. The limb was placed, on this occasion, on a splint extending from the foot to half way up the thigh, and, as perfect extension was impossible, for the knee had become fixed at an obtuse angle, it was laid upon the external side, and kept immovable in the position which gave him the least pain. It now became needful to attend to general constitutional treatment, so as to prepare him for the operation, and give it the best chance of success. He had occasional shiverings and a slightly increased evening temperature, with a slight amount of night perspiration, indicating by this advent of hectic the probable formation of matter. After he had been in the hospital for about three weeks, namely, on the 10th of March, Dr. Morgan examined his condition, and reported that his chest was free from disease, that the kidneys were healthy, and that, although the tongue was always furred and coated from old indigestion, the assimilative functions were not seriously damaged. He was ordered to take nitro-muriatic acid with a slight bitter, and after

this the ferrum redactum in the form of a pill after each meal. As soon as his health had somewhat improved, as indicated by the diminution of pain, better nights, and less tendency to perspiration, the pulse, however, remaining somewhat quick, it was determined to perform an operation, the patient having consented that, if possible, it should be excision of the knee. Nevertheless it was agreed that, if it should be discovered that the disease in the bones extended far from the joint in either direction, the thigh should be amputated. Preparations were made beforehand to place the limb (in the event of excision) in that form of apparatus so well described and so successfully employed by Dr. Patrick Heron Watson, of Edinburgh, and explained in his essay on 'Excision of the Knee-joint.' A careful measurement was made of the opposite limb by which to form a wooden splint, of Gooch's pattern, so as to fit the leg and thigh, but hollowed out at the knee to facilitate access to the joint after the operation. A piece of stout iron wire was also bent upon the sound limb in the form suggested by Dr. Watson, to enable the limb to be slung from one of Salter's swinging cradles, and the accessories in the way of plaster of Paris and suitable bandages were all ready when the operation was commenced. This was done on the 8th of April, in the following manner:—

The instruments which were to be used were placed in a warm solution of carbolic acid and water, in the proportion of rather less than one part of acid to forty of water, and those used were replaced in the fluid, from time to time, in the progress of the operation. The sponges, which were perfectly new for the occasion, were rinsed out of the same solution, and the surface of the limb, immediately before the operation, was washed over with the same liquid, and this was done so carefully that no portion of the skin near to where the wound was to be made could be otherwise than disinfected from any impurities which might have rested upon it. The patient being placed under the influence of chloroform, the usual semilunar incision was made from condyle to condyle, across the centre of the ligamentum patellæ, until the joint was freely opened, and, as soon as this was done, an assistant was instructed to inject into the joint some of the same weak antiseptic solution, and at intervals during the operation this process was repeated, as far as

possible, with the syringe, so as to keep the exposed surfaces perfectly wet, and protected from the air. The whole of the interior of the knee was found to be completely disorganized; the upper chamber of the joint, where the synovial membrane extends above the line of the patella, was entirely filled with pulpy matter. One of the crucial ligaments, the posterior, was quite destroyed by ulceration, and the other was partially affected in the same way. The cartilage was abraded from one half of the surface of the patella, and the same condition was observed on the condyles of the femur on their more convex portion, and also upon the head of the tibia. The semilunar cartilages were not much diseased. I removed with the saw about one inch and a half of the femur, and nearly one inch of the tibia; indeed, in the case of the femur, as it was necessary to cut off three successive pieces, the aggregate length of bone taken away may have been rather more than what I have just stated. The first portion sliced off from the femur was about five eighths of an inch in thickness, and this exposed a small localised abscess in the cancellated structure. As soon as this was opened another made its appearance, and after this a third, each about the size of a small hazel nut, until it was evident that the end of the femur was the seat of many of these depôts of matter. I had, therefore, to gouge out, with great perseverance, almost the whole of the lower part of the cancellated portion to a considerable depth, leaving, as it were, a mere shell of peculiarly hard compact bone forming the outline of the condyles. In the tibia I had only to remove one slice rather more than three fourths of an inch in its thickest part before I came down to healthy bone. During the whole time in which I was engaged in gouging out the diseased bone and clearing the abscesses, a stream of the antiseptic fluid was constantly poured over the surface, or projected forcibly upon it and into recesses in the bone, by means of the syringe. Only three small arteries required ligature, and they were situated in the neighbourhood of the lateral ligaments of the joint. For this purpose I used antiseptic ligatures, made by steeping ordinary dentist's silk in wax mixed with a tenth part of carbolic acid. The ligatures were cut off short, and the ends left in the wound. To protect

the popliteal artery from injury during the sawing of the bones, I used, with great advantage, a very thin ivory spatula, which, being slightly flexible, could be pressed closely against the structures behind the bones, and served as a very convenient surface upon which to direct the instrument, which in this case was Spence's saw with moveable back. After some delay and difficulty I got the ends of the bones into very fair contact without any undue tension of the parts in the popliteal space. The wound having been again most carefully syringed, its edges were brought together, and five antiseptic sutures were used to keep them in contact. The part was then enveloped in strips of lint dipped in the antiseptic fluid, and over these some gutta percha to keep them in position, and then the limb was gently placed upon the hollow splint which had been prepared for it well lined with very soft woollen cloth, and it was fixed in it by a wove bandage, the part, however, which was involved in the operation being left untouched by the bandage, as it was already covered by the gutta percha. The wire bar was then applied and fixed in position by strips of adhesive plaster. A second wove bandage was next put on, and while this was being done plaster of Paris and water, thinly mixed, were copiously applied between the folds and turns of the bandage. When this was finished and the limb seemed to be in a suitable position, the whole was covered with a thick layer of plaster of Paris, smoothed down by the hands, until it became quite solid. It could then be seen what an extremely useful form of apparatus the plaster of Paris, or gypsum bandage really is for keeping a limb perfectly immoveable after such an operation as this, and how much it must contribute to the comfort and ease of the patient to have such a safe and firm support. By this means we overcome the great difficulty in the management of excisions of the knee-joint, that, after the operation, much distress is caused by the tilting up of the lower end of the femur from the dropping of the pelvis as the patient sinks down in the bed. In my patient's case, by this admirable plan of Dr. Watson's, and the other attendant details which I closely followed, every portion of the limb was kept equally fixed and steady.

About six hours after the operation, when the surface of the

plaster of Paris had become nearly dry, I covered it with melted paraffine, painting it on with a stiff brush, and forcing it well into the porous structure of the plaster, so as to correct its tendency to break and peel off. There was no difficulty in doing this, as the paraffine is extremely fluid and limpid when heated, and solidifies very quickly as it cools. When this had been done, and the limb by the wire portion of the apparatus had been slung in a Salter's fracture cradle, I proceeded to dress the wound for the first time. I must observe that, after the operation, before the limb was placed in the splint prepared for it, I had placed two pieces of lint on the part of the splint behind the knee-joint, where the woollen cloth was covered with a layer of paraffine so as to form a smooth surface. Each piece, about eight inches wide and twelve long, was laid crosswise upon the splint. The limb with its dressings were then placed upon the splint, and, as I will presently explain, the presence of these two pieces of lint beneath the knee-joint, when it had been securely fixed in position, were, throughout the whole of the subsequent treatment, of the greatest possible service, by affording a ready means of changing and readjusting the dressings; for, while it is easy enough in these cases to clean the front of the joint, there is always a difficulty in removing the discharges which run down at the back part, but, by this arrangement, all that we had to do at each time of dressing was to attach with a needle and thread a fresh strip of lint to one or both of those already beneath the knee; the soiled ones could then be withdrawn, and new ones substituted while the under part of the limb was wiped and dried as they passed beneath it. This was what I did in the first dressing on the evening after the operation, and I also put under the knee a large piece of the lac plaster of Professor Lister, which was drawn into position by the same plan of proceeding. From the wound itself I carefully removed the gutta percha and the strips of lint, and an assistant caused a constant stream of the warm antiseptic lotion to trickle over the surface, and forced a certain quantity of it into the interior of the wound. I next folded over the wound the lac plaster, covering it up carefully, and surrounding it with folds of dry lint, and a light bandage

to keep all in position. There had been no unusual oozing of blood; the patient seemed very quiet and composed, with comparatively little pain, and much delighted to see his foot in position, and that the operation performed had been excision rather than amputation. In the night he was somewhat restless and disturbed by vomiting, most likely from the effects of the chloroform, but the hypodermic injection of a quarter of a grain of morphia quickly produced refreshing sleep, and the next morning he seemed to suffer but slightly from the effects of the operation, although it had been prolonged and tedious in its performance; and it was remarkable to observe the total absence of everything like severe constitutional distress.

On the second day, under a stream of the same lotion, I removed all the dressings, instantly covering the parts with a layer of wet lint, and re-applying the lac plaster in such a way that there was no actual exposure of the surface of the wound to the air. This was done without disturbing the patient at all, the limb swinging freely in the cradle, and by the simple arrangement of having a layer of lint already beneath the knee fresh pieces were drawn through so as to wipe the under surface, and a further portion allowed to remain there ready for the next dressing. In addition to the other pieces of lac plaster, I now put a very large piece of it round outside the dressing, so as to cover in the whole of the joint, including even the narrow portion of the splint under the knee, but next to the wound I only placed the lac plaster, without anything being interposed. The same process was gone through on the second day after the operation, and the only thing then noted was that a good deal of coloured serous discharge had escaped, and, from the somewhat raised position of the limb, had run downwards towards the hip, where it was allowed to fall into some folded lint enclosing a little oakum, so as to form a sort of pad or cushion. As far as the surface of the wound could be seen in shifting the plaster, it appeared to be smeared over with a layer of opaque white lymph.

On the third day, for the first time in changing the dressings, I placed a layer of the oiled silk protective next to the wound, the other dressings being the same, and the joint being cleansed

and wiped from any discharge by the change of lint already described.

On the fourth day the same thing was done, and it was apparent that considerable change was going on in the wound itself. No pus could be seen, but a considerable thickness of lymph was observable spread over those portions of the lips of the wound where the edges of the skin were not perfectly in contact, especially at the two cornua of the semi-lunar cut, and here there was some bulging of the deeper structures. At first, I feared that the surfaces at this part were blocked up by coagulum and that a proper discharge from the deeper parts of the wound would not take place, for the skin around exhibited that change of colour to a yellowish tint which seemed to indicate either slight effusion of blood into its substance at the time of the operation, or some other change, the result of undue pressure, but, happily, this sign disappeared in a few days.

On the fifth day the wound was not dressed, for all seemed to be going on well; the discharge was of the nature of coloured serum, quite free from smell and not in any large quantity. The pulse was just about 100 per minute, or a little below that rate, the temperature was not much beyond the normal point, and with the help of a quarter of a grain of morphia, given hypodermically each night, he slept well and without disturbance.

On the sixth day I proceeded exactly in the same way as before to dress the wound, and this was done so carefully that no portion of it was exposed to the air, and I could only, therefore, judge of the nature of the secretions by observing on the oiled silk, when removed, a little pinkish mucoid pus, in which the most careful microscopic examination failed to detect any distinct pus-cells.

On the eighth day the wound was dressed again, and exactly the same condition of things was found, namely, a total absence of fœtor, very little discharge, no pus, and the matter upon the dressings still of that mucoid character like lymph in a stage of development nearly approaching to the formation of pus, but not quite so advanced.

On the tenth day the dressings were changed as on the eighth, but close observation elicited nothing requiring further note.

This plan was followed on each alternate day, until the twentieth day after the operation, when, as must specially be recorded, a very thick layer of mucoid matter, almost amounting to a fibrinous deposit, could be seen covering over the granulating surface on each cornu of the wound; and, as far as could be told by what could be seen through the transparent oiled silk protective, the greater portion of the wound, in its central part, was fairly united.

After the twenty-fourth day, I allowed two whole days to elapse between each dressing, and this did not seem in any way to affect the progress of recovery. There was a little difficulty in preventing the serous discharge, which still continued to a slight degree, from percolating down the thigh between it and the inside of the splint, but, by stuffing in at this spot a little lint and cotton wool dipped in melted paraffine, this was checked, and the discharge then escaped by the upper edge of the outside covering of lac plaster where a pad of oakum was placed to receive it.

On the thirty-seventh day, I ascertained that the internal cornu of the incision was healed, or as nearly so as possible, but on the external side there was still a very large projecting granulating surface. The sutures were still untouched and did not seem to have produced any irritation. No pus could be recognised in any way adhering to the surface of the dressings or floating away from the wound, but about thirty or forty drops of thick mucoid matter remained adherent to the oiled silk each time it was removed.

On the fifty-sixth day I had an opportunity of again examining the wound very fully, and it was evident that the internal cornu of the wound was more nearly healed than the external, and that the edges of the wound in the middle were closely united.

On the sixty-second day, I observed that, at times, a little coloured serum, which came from the granulations, still escaped from the edge of the outer covering of plaster, and fell into the oakum pad, as previously described. The plan of using oakum for this purpose I found to be a very useful one for collecting the discharge; besides it served both to absorb and dry it up, and thus also

to prevent putrefaction. Oakum is a substance, however, which has a rather disagreeable penetrating odour, which renders its use, in many cases, objectionable.

I allowed this state of things to continue, without any variation in treatment, until so long a period as the seventy-fifth day after the operation. Dr. Patrick Heron Watson, in his valuable monograph on excision of the knee-joint, to which I am greatly indebted and all the details of whose practice I sought to carry out as completely as possible, makes the remark that in one case, he allowed the joint to remain in the plaster of Paris splint, without disturbance, for so long a period as sixty days. I did not hesitate, therefore, in this instance, seeing the many difficulties which attended upon the operation and the extensive disease of the bones which was then revealed, to keep the limb untouched until after the seventieth day.

On the seventy-fifth day, however, I removed the five sutures in the line of incision, and, in so doing, for the first time I observed one or two drops of pus, as if one or more small localised abscesses had formed in the neighbourhood of the sutures. This was, in fact, the only occasion during the whole of this long period on which I could fairly say I saw anything like true laudable pus.

On the eighty-fifth day, just twelve weeks and one day after the operation, I removed the wood and plaster of Paris splint, in which the limb had lain so long. I found as I expected, that the under part of the thigh was considerably stained and soiled by the discharge of coloured serum, which, in the early days of treatment, had trickled down, insinuating itself between the thigh and the lining of the splint. With this exception, the limb appeared to be in a very healthy state, and, guarding the surfaces of the wound with a wet lint covering as usual, I quickly readjusted the dressings, placing the oiled silk next to the surface, and one or two folds of lac plaster around. The limb was then placed in a wooden splint of exactly the same pattern as the plaster one, and lined in the same way; it was retained in position by the wove bandage, and the wire support was put on and fixed in position by another bandage of the same kind. Although the patient could not

raise his foot from the bed without some assistance, yet this could be done with very slight help. In this way the limb was again, for a few days, slung in the cradle as it had been before. At times, the chains were detached from the hooks and the limb was allowed to rest on the bed. All seemed to be doing well, when, unfortunately, I allowed too long an interval to elapse between the dressings. I was led into this delay by two motives; first, because I hoped, from the very healthy state in which I had left the wound, the large amount of lac plaster in which I had encased it, and the great extent of surface over which this was placed, at least, eight inches above and below the wound all round the limb, that putrefaction would not take place. The other inducement was, that I should have had to move the limb and lift it out of its splint before I could change the dressings, and this I was especially anxious to avoid, as I did not want to disturb my patient. Acting on this idea, I allowed more than one week to pass by, and it was fully eight days before I opened the bandages. I then discovered what a serious error I had committed, for, on changing the dressings, it was quite evident that the discharge at the edges of the plaster had become fœtid, and putrefaction in some degree had commenced; although the discharge which was found within the folds of the lac plaster and on the surface of the oil silk was not truly purulent, it was much more of that character than I had ever before observed. The dressings were re-applied in the same way, with a larger quantity of oiled silk and three folds of lac plaster immediately over the wound.

Four days after this, as is noted in my report, the patient showed considerable power in moving the limb, for, while it was still fixed in the wooden splint but without the wire rod, he could, by his own muscular action, raise the limb off the bed with great ease. Encouraged by this state of things and still loath to remove the splint more often than was really needed, I was again induced to allow six whole days to elapse before I re-dressed the wound, when, in spite of these favorable symptoms, the fœtor was even greater than it had been previously, and the discharge decidedly purulent. Thinking therefore that possibly in this way

of dressing the part air might enter beneath the folds of the lac plaster, which it was very difficult to adapt with perfect accuracy to the exact form of the limb, I determined now to envelope the whole of the surface next to the skin in a single fold of linen previously dipped in carbolated oil and sewn on to prevent it from being raised. This was done in accordance with a method adopted by Mr. Bickersteth, of Liverpool, in a very interesting case of incision into a diseased knee-joint, which he described in the 'Lancet' of 2nd July, 1870, where he used, with wonderful success, the carbolated oil dressings, keeping on unchanged for many weeks the same piece of linen next the wound, and only renewing the superficial layers of lint from time to time. With this object, I caused a piece of oiled linen to be fixed round the knee so that it might fit it closely, and over it I placed a large piece of lac plaster, and, this being carefully adjusted, I put at each end of it a smaller piece which, being about six inches broad and long enough to encircle the limb, would have half its breadth beyond the edge of the larger piece and the other half resting upon it. The intention of this was that I might only remove the large piece of lac plaster once in six days, but the small pieces which would receive the discharge at shorter intervals, and that the piece of oiled linen might be kept on permanently. With this intention I removed the smaller pieces of lac plaster on the third day and the larger likewise on the sixth, yet, it became clear that, even with this arrangement, the putrefaction which had unfortunately been set up in the secretions of the wound could not be completely arrested, although in some degree it had been kept in control. It became necessary therefore once more to alter the plan, and on the 9th of August, being the 124th day in the treatment of the case, I returned to the use of the oiled silk protective next the wound, and the large piece of lac plaster round the joint with smaller pieces at the ends, which could be frequently changed; and by steady perseverance in this plan, towards the end of August I was rewarded by finding that all unpleasant smell had ceased, the discharge had resumed the flaky character of mucoid pus, and as the unfavorable condition of the wound subsided, matters could once more be reported as being *in statu quo* it was before putrefaction had been

allowed to commence, and, from this date to the time at which I write, the 10th of September, the case has gone on as favorably as could be expected.

Taking in review the drawbacks and difficulties which I have described in this case, if it were only adduced as an illustration of what may be done by careful attention to the antiseptic method of treating wounds, it must be regarded as very instructive, both as showing favorable and unfavorable results. That so large a wound as that produced by excision of the knee-joint with the lacerations of structure which must occur at the time of the operation in sawing and gouging the bones, detaching the soft parts, and replacing them in position—that all this should thus be restored by nature to a healthy state without the advent of suppuration, which is so generally attendant upon large wounds, must be a matter of astonishment to all who have watched the progress of such a case as this. I know it will be said that instances are on record, in cases of excision of the knee-joint—Dr. Watson himself refers to one—in which, from first to last, with very few dressings, hardly any pus at all was formed, and the wound healed most satisfactorily. Here it might be said *exceptio probat regulam*, and what has occurred may occur again. But, if so, it will still be the exception, and it should be our effort to make so favorable an event not the exception but the rule. If by any method of treating wounds we can avert the presence of suppuration or diminish its amount, not only do we avoid those risks of constitutional disturbance which often reduce the strength of the patient by exhaustion of the nervous system, but we likewise save that general drain which must result from the secretion of a large quantity of matter. Now, it will be seen in this case, that, up to so late a period *as the seventy-fifth day after the operation*, the wound had passed through all the stages of repair, in which it may be said to have been first in the condition of a compound fracture, and after this, the external wound being nearly healed, to have presented changes such as are incident to the repair of a simple fracture; yet, all this was done and done effectively, without the formation of any pus, if we except the one or two drops which were found in the line of the superficial sutures. Then came the unfavorable condition of the

case, when, by the unfortunate delay in the time of dressing, for which I am personally responsible, air obtained access to the unprotected surface of the wound, and the secretions becoming vitiated and putrescent stimulated the vessels of the granulating surface, and caused them not merely to secrete reparative lymph, but that degradation of tissue which we designate pus.

To correct this condition, and to bring the action again to the previous state, was indeed a difficult task, and it affords an illustration of the fact, which those who have watched the action of antiseptic dressings in surgical cases must know full well, that it is far easier to *prevent* the accession of suppuration in the first instance in the managment of wounds by the antiseptic treatment than, when it has once set in, to *arrest* its progress, and stop entirely that ceaseless tendency which the capillaries of the part then exhibit to carry on the inflammatory changes to that particular degree. Thus it is, as Professor Lister has so well taught, and, as all who have followed his observations must admit, that the greatest care is requisite in the first few days of treatment, and that too much attention can hardly then be given to all those minute details in manipulation, which are so often neglected, and which those, who have not practised them and seen their good effects, are apt to regard as superfluous or unnecessary. For, it is during the first five or six days in the treatment of any wound, that the greatest tendency exists in the inflammation to run on beyond the stage at which we desire to detain it. When once established, suppuration is with difficulty checked, and hence, in every case, we lose our main chance if we do not begin the treatment at the earliest possible moment. In dealing with matters of fact, some minds seem to be so constituted that they can look to general principles alone, while others are prone to waste much time and energy on detail only. The happy medium we should seek is to look chiefly to the essentials, and if it can be shown that any points of detail are essential to the perfect success of the treatment in question, then, no matter what the time and labour which may be required, these ought to be carefully observed and most rigidly carried out.

At the beginning of the antiseptic method of treating wounds

many plans were suggested which have since been laid aside, and even now it must be admitted that the system is in its infancy; for, speaking as to time, it is not much more than three years and a half since it was first brought before the notice of the profession by Professor Lister, and it is not much more than one year, if so long, since the lac plaster and the oiled silk protective were first employed, so that we may fairly hope, when these appliances have had a longer trial, we may learn, with certainty, what are the special conditions which must never be violated and in what respects we may occasionally deviate from them, and yet not fail in securing results which, when obtained, are of incalculable value.

Nothing short of daily practical experience—not the experience related in books, but that which is demonstrative and positive—will ever determine how far the antiseptic method is applicable to the general treatment of surgical cases.

It may be said, if its success depends upon the use of a particular plaster or a particular covering, as the oiled silk protective, that, as these are not always obtainable, it is not a plan of dressing suitable for general practice. But, we may rest assured that, as soon as we are convinced that a principle has been discovered, namely, the need of the entire avoidance of putrefaction in the secretions of wounds in whatever way that can be effected, either by excluding air, or by rendering it innocuous, we shall not care to contend for what are mere questions of detail. If this great fact be once established, that to avoid putrescence is to control the progress of inflammation as far as unfavorable conditions are concerned, then we may hope to discover some other mode of dressing wounds, which, acting precisely according to the same laws, shall be more easily procurable, and, it may be, more easy of application than the lac plaster and oiled silk protective which are so closely associated with the name of Professor Lister.

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